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INJURY RISK REDUCTION PROGRAMS FOR FIREFIGHTERS—A CASE EXAMPLE

Injury prevention, or more specifically, musculoskeletal injury (MSI) prevention is often a topic of discussion for senior command in professional fire departments, and with good reason. MSI can account for 57% of all injuries suffered by firefighter personnel, on and off the fireground (9). Furthermore, MSI can affect the personnel pool, burdening the fiscal solvency of a department, which must either backfill these positions or send crews out at dangerously low staffing levels (8). In the example used for this article, from 2013 – 2015, the Fairfax County Fire and Rescue Department (FCFRD) spent over 19 million dollars on MSI treatment, rehabilitation, and backfill.

Given these costs, it should come as no surprise that there is enormous pressure on occupational medicine professionals serving tactical populations to come up with injury prevention solutions and in doing so, show a cost-saving benefit to justify their funding. Consequently, the efficacy of occupational medicine providers, such as Tactical Strength and Conditioning Facilitators® (TSAC-F®), Certified Strength and Conditioning Specialists® (CSCS®), physical therapists, and exercise physiologists, is judged heavily on their ability to affect change in this arena. To this end, tactical facilitators are faced with two challenges: 1) come up with a solution to identify MSI risk and 2) show the efficacy of injury risk-reduction programs.

These MSI interventional efforts are traditionally called "injury prevention programs." It is suggested, however, that approaching this problem with the mindset of preventing MSI is a bit of a fool's errand. This is an assertion confirmed by the statistical premise that is inordinately difficult to prove prevention—the causation versus correlation premise (11). Moreover, the phrase "injury prevention" has become the de facto title of occupational medicine efforts to this end, and predisposes any such program to "prove prevention" in order to confirm efficacy and justify funding. Therefore, it is imperative to adopt both a mindset and a vernacular that emphasizes "risk reduction," and in fact, that is precisely what these programs are attempting to do. Furthermore, taking a risk-reduction approach can produce quantifiable metrics where tracked injury rates indicate a reduction in injury rates, near misses, and exposure due to a specific intervention program.

The responsibility to meet the challenge of curbing MSI in the fire/rescue service has been addressed by the program implemented by FCFRD's Wellfit Division, the department's in-house fitness and rehabilitation center. Wellfit is led by a CPT II and staffed with a Peer Fitness Trainer Coordinator (PFTC), a director of strength and conditioning, a physical therapists, and a team of Peer Fitness Trainers (PFT). It was agreed that the first steps involved a closer examination of injury data (e.g., nature, body part involved, mechanism) and the development of a strategy to identify at-risk personnel. Analysis of injury data revealed several key components of the personnel's MSI profile that needed consideration. First of these was that the overwhelming majority of MSIs were to the lower back, shoulder, and knee (Table 1). Low back injuries are the most common MSI in the fire service, and account for the largest percentage of MSI expenditure (12). As the FCFRD processed their injury data in greater detail, it became abundantly clear that the predominant mechanism of injury for low-back injuries was lifting (Table 2). The next step was to determine the best way to identify those personnel who might be predisposed to injury.

MOVEMENT SCREEN CONSIDERATIONS

Movement screens have been used in various forms to identify movement/mobility dysfunction with varying degrees of success. Among established movement examinations, the Functional Movement Screen™ (FMS™) may be the most widely employed. Consisting of seven movement demands, the FMS is intended to provide an assessment tool for ascertaining the competence of an individual's movement (5). The FMS has been shown to be an apt tool for performing gross movement screening on the general population and for eliciting a positive change in movement patterns (5). However, it has been demonstrated that there are components of the FMS that can potentially invite inaccurate assessments of movement proficiency, especially in tactical populations as it relates to movement proficiency in a high-stress environment (4). The most notable of these components, as they relate to tactical populations, are the absence of exertional factors (e.g., load, speed, fatigue) and the equivocal nature of quantifying movements of varied complexity with a limited ordinal system (1,2,4,6,7,10).

Returning to the example program implemented by the FCFRD, there were several challenges in constructing a screen for the department. The screening events needed to be specific to fireground activities but also mimic typical functional movements, create a positive attitude towards the screening, select appropriate movement demands, take time-constraints into consideration, and incorporate both load and fatigue. Given that the intention was to reduce the risk for lower back, knee, and shoulder injuries, movements needed to be selected so that they might help to rule out dysfunction for the lumbo-pelvic system, the lower extremity, and the shoulder girdle, respectively. The input of the PFTs was invaluable during this process. Another consideration was the desire to move away from the nomenclature and mindset of "screening," to something more supportive and constructive. A "workshop" seemed to be the perfect solution and was selected as the designation for this department's "screening" process—the FCFRD's Functional Movement Workshop (FMW).

TABLE 1. DISTRIBUTION OF MSI SITE OF INJURY WITHIN FCFRD

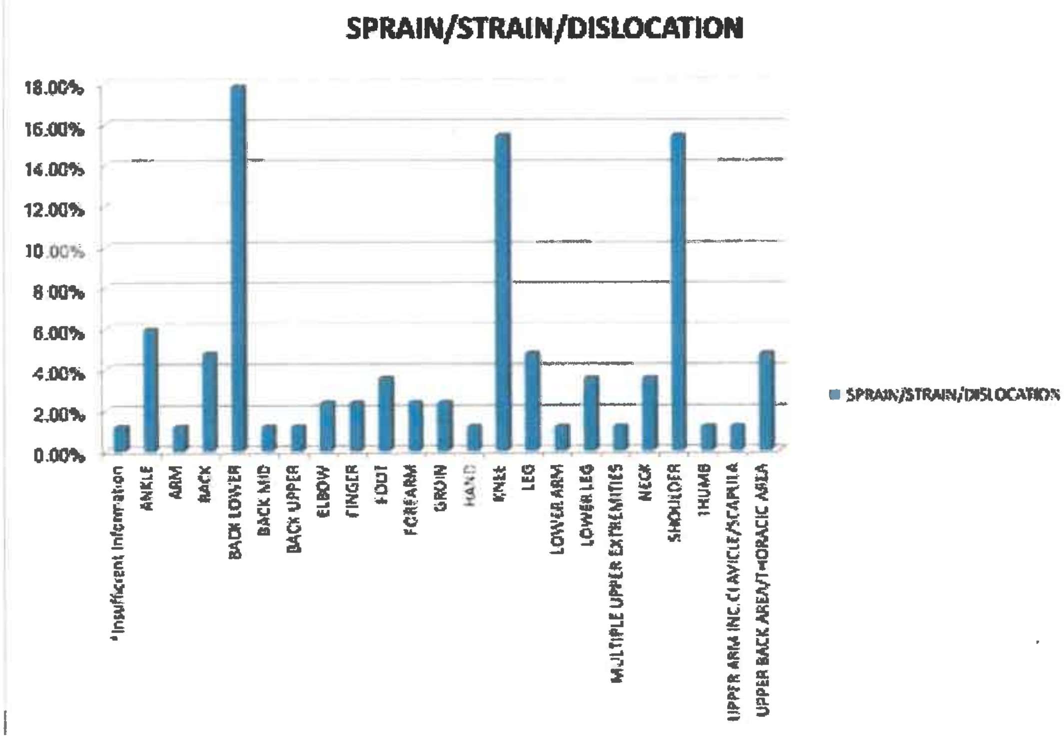
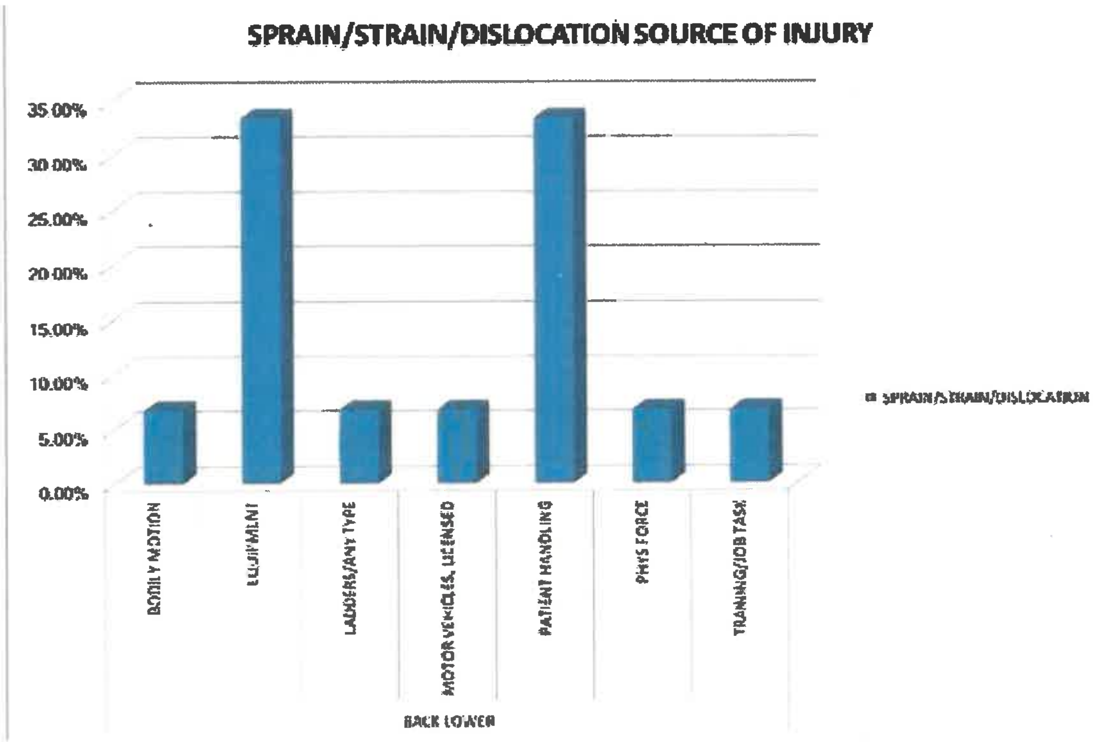


TABLE 2. MECHANISMS OF LOWER BACK INJURIES



The movements selected to populate a three-event format were the deadlift, in-line lunge (ILL), and overhead press (OHP). Although the initial movements are described as "unloaded," it was decided that incorporating a baseline load on the deadlift and overhead press was necessary to create realistic mechanical demand and a degree of perceived risk. To justify the loads prescribed, a functional justification, or "tactical link," had to be established. This was necessary to validate the magnitude of the load and address the need for parity of effort across the department's population. Time constraints were another issue, as obtaining out-of-service time on an already engorged master calendar can be next to impossible. The solution was a format that required only 30 min of out-of-service time and also afforded one-on-one interaction between the staff and each firefighter. Lastly, the program needed to incorporate load and fatigue. This was accomplished by inserting a short but intense session consisting of exercises performed with as many repetitions as possible (AMRAP). Afterwards, the firefighters donned a self-contained breathing apparatus (SCBA) and repeated the screening events (Table 3).

THE WORKSHOP FORMAT

In the example of the FCFRD program, a staff of 4 – 5 (2 – 3 PFTs, the strength and conditioning director, and the PFTC) set up in the bay of the predesignated station. Crews were scheduled through the battalion to rotate through every 30 min. Incoming crews filled out the FMW worksheet information section which included their MSI history, were briefed by the PFT coordinator, and then assigned to an individual PFT. The workshop then proceeded with detailed instruction and a demonstration of what was expected for each particular movement, including a comprehensive explanation of the screening criteria. Some argue against this method purporting that it cues the participant too much and possibly white-washes existing movement dysfunction (3). The goal was to raise awareness, coach, and educate the individuals involved in the program, so the FCFRD set out to give the firefighters every possible advantage to realize improved biomechanics.

The active portion of the workshop followed the instruction. The firefighters performed the prescribed movement while unloaded and unfatigued. The PFT paired with each firefighter observed them from multiple angles, annotated the workshop sheet, and used the workshop guide as a resource/reference for coaching the movements (Tables 4 – 6). At the completion of the third event, the overhead press, the PFT took each firefighter through five minutes of the AMRAP session. While this was done in a self-paced fashion, the firefighters were encouraged to work as hard as possible. This also provided an invaluable coaching opportunity and another platform for raising awareness. Form and movement decrements were documented on the workshop sheet (Table 7). At the immediate conclusion of the AMRAP session, the firefighters donned the SCBA and repeated the events. The PFT observed the firefighters again and annotated movement and postural anomalies.

TABLE 3. AMRAP SESSION

FUNCTIONAL MOVEMENT WORKSHOP INTERVAL CALISTHENICS—5 MINUTES
10 free-standing squats
30 jumping jacks
10 down-ups/burpees—to standing only (no jump)
10 counter-movement jumps
10 push-ups (hands or knees)
10 alternate forward lunges (5 each leg)

TABLE 4. DEADLIFT COACHING GUIDELINES

Deadlift:

Address

a. Bar Position – Barbell should be close to the tibia/shin to facilitate keeping the load nearest the center of gravity.
b. Foot/hand placement
   i. Feet – should be positioned under the shoulders and aligned so that the axis of knee flexion/extension is parallel to the line of the foot and femur
   ii. Hands – Generally positioned on the bar under the shoulders. Grip can be traditional or off-set.
   iii. Shoulders – should be just anterior to the bar
c. Joint Stack – From the floor up, the knee, hip, and shoulder should be positioned in order, respectively. I.e. the hip should not be at the level of, or below, the knee and the shoulder should not be at the level of, or below, the hip.

Spine

d. Curvatures - As observed in standing posture, curvatures of the spine should be maintained from address to completion and back to the floor. i.e. the gentle extension curves of the Lumbar and Cervical spine, and the moderate flexion curve of the Thoracic spine.

Lift Mechanics

e. Up (knee ext; hip ext)
   i. From the floor, the bar should be accelerated by knee extension until the bar reaches the knee joint. This can be observed by gauging the rate at which the hip and shoulder rise – this pace should be symmetrical.
   ii. Once the bar reaches the knee, the hip should begin to "un-hinge" – hip extension as the knee continues to extend. At the finish, the shoulders should be vertically loaded just slightly posterior to the hip. The hip should be loaded directly over the knee. The knee should be slightly flexed or "soft" (Never "locked" when loaded)
f. Down (hip flex; knee flex)
   i. The initial lowering action should be a hinging of the hip joint, with the soft knee position remaining largely static. This causes the hip to move posteriorly and shoulder to move anteriorly as the lifter maintains the center of mass over the center of gravity.
   ii. When the Barbell is at the knee, the knee should begin to flex and hip flexion (hinging) essentially stops. A rigid trunk and hip maintains stability while the flexing knee lowers the barbell to the floor.

TABLE 5. IN-LINE LUNGE COACHING GUIDELINES

In-Line Lunge

Trunk/Dowel

a. Hip/shldr velocity equal – Do the hip and shoulder move in unison (at the same speed). This is especially important as the participant returns to standing from the lunge. Asymmetrical trunk/hip velocity can indicate one of two deficiencies:
    i. Weak/inactive trunk extensors (glutes, erector spinae, et al). The hip will move with more velocity than the trunk and the spine will tend to collapse into flexion and lag the pace of the lower body. The trunk "catch up" to the hip very gradually throughout the return phase of the lunge.
    ii. Weak knee extensors/arthritic or degenerative changes in the knee. The knee extensor mechanism cannot generate enough force (or the pain is prohibitive) to overcome the moment-arm of the trunk as it accelerates with the center of mass, the trunk will flex; decreasing the moment arm and allowing the knee extensor to elevate the body's center of mass. The knee and hip then briefly act isometrically and the trunk will "whip" into extension; overcoming the inertia of the moment arm and gaining the momentum necessary for the participant to return to standing.

b. Remains vertical – The dowel should remain vertical in both the sagittal and frontal plane throughout.

c. Maintains Contact - The participant should be able to maintain contact with both hands (behind head and against the lumbar spine) throughout the movement.

Knee Joint

a. Alignment – As the participant lunges, the knee should flex along a line that is parallel to the centerline of the foot.

b. Touches Beam – the participant should have a level of overall strength and mobility that permits them to lunge deeply enough to touch the beam with the trailing knee.

TABLE 6. OVERHEAD PRESS COACHING GUIDELINES

Overhead Press

A-P View

a. Symmetry – Each upper extremity should move in unison; same angles, same pace. In the finish position, the shoulder girdle should be level.

b. Load Alignment – During the press, the DB should generally stay positioned directly above the elbow. At the finish position, there should be a relatively straight line from the DB, through the shoulder, to the floor.

Lateral View

c. Load Alignment - During the press, the DB should generally stay positioned directly above the elbow. At the finish position, there should be a relatively straight line from the DB, through the shoulder, to the floor.

d. Posture – The participant's posture should remain in a relatively neutral position; with a plumb line from the DB through the shoulder, hip, knee, and ankle.

TABLE 7. FMW COACHING WORKSHEET

FCFRD Well-Fit Functional Movement Workshop

Name:		Age:		Gender (1= M 2=F):	
Date of Workshop:					
Prior Musculoskeletal Injury (y or n):		Location of Injury:		Surgical/ Medical History:	
Station or work locale/Shift:		Yrs of Service:			

Initial

Deadlift

Address

Criteria	Optimal	Non-opt	Corrected
Bar position			
Feet/Hands/shoulders			
Joint "Stack"			

Spine

Criteria	Optimal	Non-opt	Corrected
Curvatures			

Lift Mechanics

Criteria	Optimal	Non-opt	Corrected
Up (knee ext; hip ext)			
Dn (hip flex; knee flex			

In-Line lunge

Trunk/Dowel

Criteria	RIGHT LEG FORWARD			LEFT LEG FORWARD		
	Optimal	Non-Opt	Corrected	Optimal	Non-opt	Corrected
Hip/shldr velocity equal						
Remains Vertical						
Maintains contact						

Knee Joint

Criteria	RIGHT LEG FORWARD			LEFT LEG FORWARD		
	Optimal	Non-Opt	Corrected	Optimal	Non-opt	Corrected
Alignment						
Knee Touches Beam						

Overhead Press

A-P View

Criteria	Optimal	Non-opt	Corrected
Symmetry			
Load alignment			

Lateral View

Criteria	Optimal	Non-opt	Corrected
Load alignment			
Posture			

Exertion Session Observations:

Fatigued/Loaded

Deadlift

Address

Criteria	Optimal	Non-opt
Bar Position		
Feet/Hands/shoulders		
Joint "Stack"		

Spine

Criteria	Optimal	Non-opt
Curvatures		

Lift Mechanics

Criteria	Optimal	Non-opt
Up (knee ext; hip ext)		
Dn (hip flex; knee flex		

In-Line lunge

Trunk/Dowel

Criteria	RIGHT LEG FORWARD		LEFT LEG FORWARD	
	Optimal	Non-opt	Optimal	Non-opt
Hip/shldr velocity equal				
Remains Vertical				
Maintains contact				

Knee Joint

Criteria	RIGHT LEG FORWARD		LEFT LEG FORWARD	
	Optimal	Non-Opt	Optimal	Non-opt
Alignment				
Knee Touches Beam				

Overhead Press

A-P View

Criteria	Optimal	Non-opt
Symmetry		
Load alignment		

Lateral View

Criteria	Optimal	Non-opt
Load alignment		
Posture		

Additional Notes:

PFT NAME	

A critical piece of this process was video capture. The PFTs were supplied with tablets and software that allowed them to record the firefighters as they completed the workshop. The software was performance coaching software that allowed slow-motion replay and stop-action video replay. PFTs used this video capture technology to create visual feedback for the firefighters (e.g., including graphics and lines to demonstrate joint/segment angles, postural alignment, rates of change, and positional changes). It would be difficult to overstate the impact that this has on increasing awareness and improving the coaching experience for all concerned (Figures 1 and 2).

MOVEMENTS

DEADLIFT

Observation of the deadlift can reveal a host of sub-optimal components as they relate to a firefighter's lifting technique, such as the position of the load in relation to the firefighter, position and posture of the firefighter as they address the load, sequencing of movement systems, and lumbo-pelvic stability and posture. Another consideration included in the performance of the deadlift is the weight of the 24-ft ladder, which measured 73 lb in the FCFRD facility. Therefore, the load applied to the deadlift movement was 70 lb, which consisted of an Olympic bar and 2 x 15 lb bumper plates.

After instruction and demonstration, the firefighters performed the movement. The PFT had complete autonomy and allowed the firefighters to perform several repetitions if necessary (Figure 3). In the second round, after the AMRAP session, the firefighters repeated the deadlift wearing the SCBA (Figure 4). During both evolutions, movement deficiencies were noted on the worksheet and they coincided with the coaching guidelines established by the facility.

IN-LINE LUNGE

The set-up for the ILL was essentially identical to the FMS format (Figure 5). During the ILL, the PFT assessed the firefighter's balance, lower extremity strength, knee frontal-plane stability, and lower extremity mechanics. Additionally, the PFT grossly assessed upper extremity range of motion by observing the firefighter's ability to hold the dowel rod correctly. Because assuming, and returning from, a kneeling position is a common requirement in tactical populations, the ILL was utilized because it mimicked lower extremity movement patterns commensurate with ingress/ egress of apparatus, ladder and stair climbing, and many other tactical demands.

The firefighters received instruction and a demonstration of the movement (Figure 6). After the tibial measurement was performed, the firefighters were instructed to assume the correct stance on the beam and perform the ILL with the dowel rod held vertically behind their trunk (as in the traditional FMS format). The FMS balance beam was used for the initial event. Again, the PFT observed the firefighters from multiple angles and was free to coach and mentor the firefighters at their discretion after the initial assessment was completed. In the post-exertion phase, the dowel rod was removed and the firefighters were required to perform lunges wearing the SCBA (Figure 7).

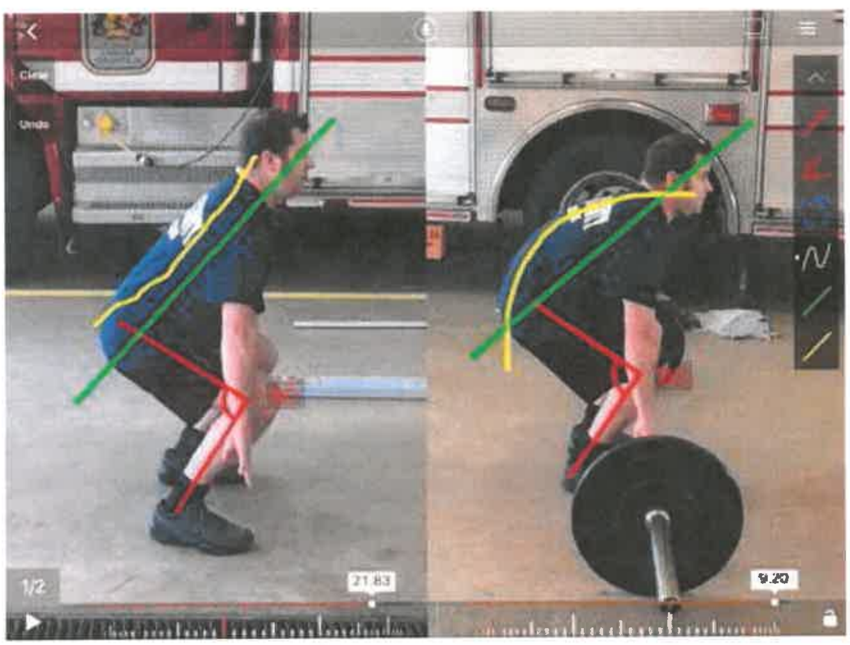


FIGURE 1. AFTER AND BEFORE COMPARISON OF DEADLIFT MECHANICS

FIGURE 2. OVERHEAD PRESS WITH OVERLAY OF ANGLE OF THORACIC EXTENSION

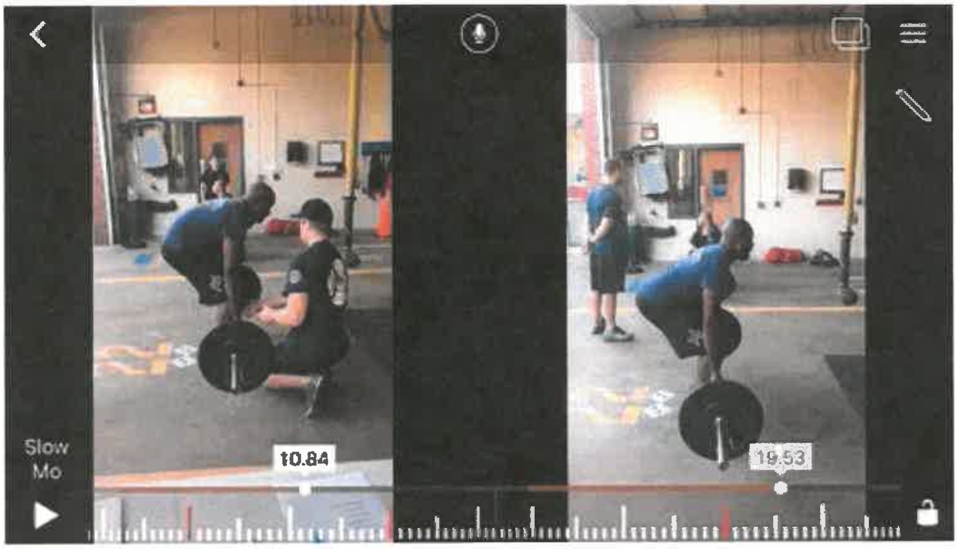


FIGURE 3. REPEATED ATTEMPTS AND RESULTS OF COACHING CORRECTIONS

FIGURE 4. DEADLIFT AFTER AMRAP SESSION WITH SCBA

FIGURE 5. ILL WITH IMPLEMENTS

FIGURE 6. COACHING ILL TECHNIQUE

FIGURE 7. ILL AFTER AMRAP WITH SCBA AND SPINE ANGLES

OVERHEAD PRESS

The issue of how to approach screening for shoulder injury risk is a difficult one. The approach of thoroughly examining the mechanical integrity of the shoulder is as complex as the joint itself. In order to maintain the efficiency of the workshop and stay within the scope of practice for the staff, it was decided that the overhead press was suitable for the purposes of the program. A load of 30 lb (two 15-lb dumbbells) was selected, as this is approximately the force needed in order to raise one end of the 24-foot ladder, as measured in the FCFRD facility with a force dynamometer. Being that there are innumerable overhead activities required in tactical operations with varied loads and velocities, an effort was made to maintain the integrity of the intent, which was to assess the upper extremities in terms of identifying injury risk and not to assess absolute upper extremity strength.

After instruction and demonstration, the firefighters stood with a dumbbell in each hand with their elbows flexed, and positioned the dumbbells at shoulder height (Figure 8). Then they pressed the dumbbells upward until their elbows were fully extended. The PFT observed the load placement, trunk posture/stability, and upper extremity positioning/stability. After the initial observation, the PFT was free to make adjustments and provide coaching and observations relative to posture and upper extremity alignment and axial loading.

EVALUATION AND FOLLOW-UP

The PFTs utilized the workshop worksheet to guide their observations and evaluate the firefighters. Instead of an ordinal system, a nominal system of optimal/non-optimal assessment was used and applied to key movement features. These movement features became the driving force behind the evaluation format. Deviations from ideal movement patterns were noted as "non-optimal" and corrective actions were taken in the worksheet to address these issues. If the firefighter was able to correct the movement deficiency in the workshop, that component was noted as "corrected."

The greatest number of movement deficiencies observed occurred during the deadlift movement. They include positioning issues (e.g., the firefighter taking their stance too far from the load), mechanical issues (e.g., inefficient sequencing of hip/knee flexion/extension, spinal control), and mobility issues (e.g., excessive posterior pelvic tilt/lumbar flexion). Thus, the deadlift becomes an extremely effective vehicle for increasing awareness of movement dysfunction and allowed for an accepting environment for introducing corrective/protective exercises to improve firefighter performance and reduce their risk of injury (Figure 9).

FIGURE 8. STARTING POSITION FOR OVERHEAD PRESS

FIGURE 9. COACHING DEADLIFT TECHNIQUE

The ILL revealed dramatic changes in gross motor control after the AMRAP session, which resulted in losing balance. Apart from identifying dynamic internal rotation of the femur and early indications of limited shoulder range of motion, this significant decrease in balance was used to educate firefighters on the effect of fatigue as it related to their overall stability and balance. Postural issues and shoulder girdle range of motion limitations were the predominant non-optimal findings of the OHP. The OHP allowed the PFTs to observe upper extremity mechanics, axial loading of the shoulder, and the firefighter's dynamic posture.

CONCLUSION

The program implemented by the FCFRD is an example of how a department can attempt to address and potentially prevent MSI in firefighters and similar tactical populations. This process includes the use of movement screens, active workshops, and various modes of feedback based on the evaluation of movement and the specific needs of the population.

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